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INTRODUCTION

The Cooley spruce gall aphid, Chermes cooleyi (Gill.), is native to North America and is found from coast to coast in the northern United States and southern Canada. It feeds on the following species of spruce: Colorado blue, Engelmann, Sitka, and white. During part of its life-cycle, it also feeds on Douglas-fir. Symptoms of damage on spruce are large galls on the ends of twigs (fig. 1). On Douglas-fir, the needles turn yellow and twist. If feeding is heavy, damaged needles may fall off.

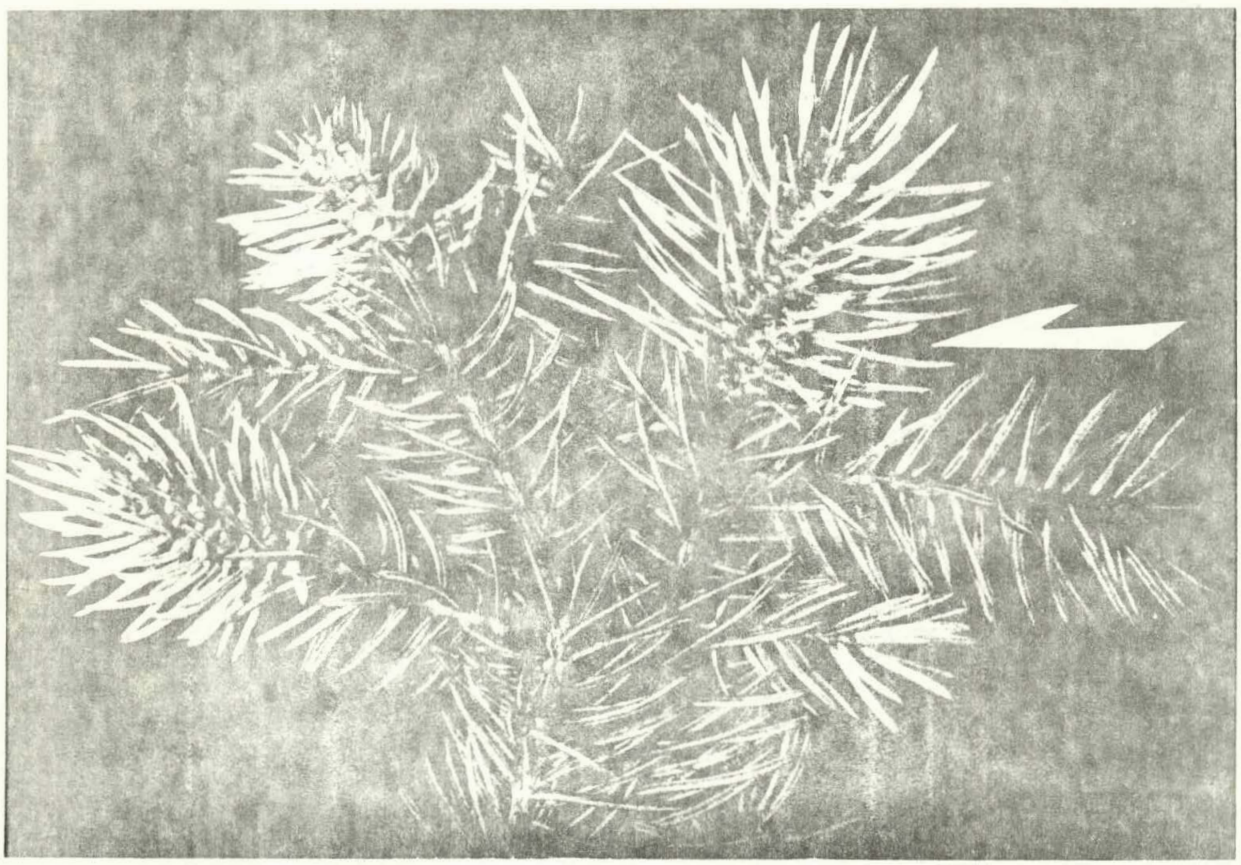

Figure 1.--Arrow points to a typical 1-year-old gall on blue spruce from which gallicolae migrantes nymphs emerged. Note openings of gall chambers at the base of the needles. There are two more galls on the ends of the twigs to the left.

1/ Order Homoptera: Family Phylloxeridae

In the Northern Region, C. cooleyi is of some concern to owners of ornamental spruce trees, nurserymen, and growers of spruce and Douglas-fir Christmas trees. Feeding damage makes these trees unsightly.

LIFE HISTORY AND HABITS

The most comprehensive publication about C. cooleyi was written by Cumming in 1959.2/ Information in this paper relating to its complex life history and habits was largely summarized and modified from Cumming's work.

The aphid goes through six different generations (egg to adult) which take 2 years to complete on spruce and Douglas-fir. This is called a life-cycle, and it begins again when a certain generation on Douglas-fir (the alternate host) migrates back to spruce. Adults of two migrant generations are the only ones that develop wings. The other four generations produce wingless adults. All six generations are present in any one year because generations on both hosts are active simultaneously.

We will now discuss each generation and its habits separately and show how it fits into the life-cycle.

The generations of C. cooleyi:

Each of the six generations has a different biological name which describes its functions. The generations and definitions of the names are listed below:

Sexualis - This is the only generation that has male and female adults. Sexual reproduction occurs on spruce.

Fundatrix - They are the foundation stock or stem mothers on spruce.

Gallicola Migrans - Develop in spruce galls and migrate to Douglas-fir.

Sistens - The word refers to a period of nondevelopment. Nymphs of this generation overwinter on Douglas-fir.

Progrediens - Progrediens means advancing. This generation can advance or perpetuate itself on Douglas-fir alone.

Sexupara - They produce progeny of both sexes. Winged adults fly from Douglas-fir and lay eggs on spruce which hatch into sexuales.

2/ Cumming, Margaret E. P., 1959. The Biology of Adelges cooleyi (Gill.) (Homoptera: Phylloxeridae). Can. Ent. Vol. XCI (10): 601-617

Sexualis on spruce

The sexuales (plural) are the progeny of the sexuparae (winged migrants from Douglas-fir in August). This is the only generation where sexual reproduction occurs. All the other generations consist of parthenogenetic females (produce fertile eggs without copulation with male). Sexuales go through three or four nymphal instars (growth stages) and feed near the nodes of old growth. After copulation, females usually lay one egg between the old bud scales and the twigs during the end of August.

Fundatrix on spruce

The fundatrices are the progeny of the sexuales and appear in September. First instar nymphs feed on the upper surfaces of the needles but usually overwinter on the stem below the buds (fig. 2). They go through two more instars in the spring, then change into adults who cover themselves and their eggs with wax. This generation is the most prolific--as many as 352 eggs can be laid by some females.

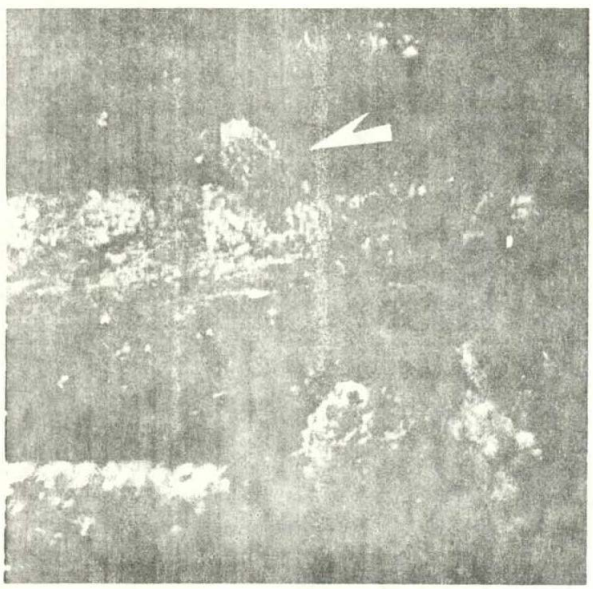

Figure 2.--Arrow points to a fundatrix nymph overwintering on an Engelmann spruce twig stem. Another nymph is located beneath it at the base of a bud. Note the fringes of wax around the edge of the body and on its back. (Nymphs enlarged about 15 times.)

Gallicola migrans on spruce

The gallicolae migrantes are the progeny of the fundatrices. Emerging nymphs move to the elongating new growth and complete galls which were started by the feeding of fundatrices. Galls (fig. 1) are formed by the swelling of the stems and of the needle stalklets and are chambered. Young galls are green and have a pink or purple tinge. Often, 30 nymphs will feed within one chamber. Nymphs pass through four instars within the galls. They are a bright reddish-brown color and are covered with a fine powdery wax. About the end of August, last instar nymphs emerge from galls, settle on needles, and change into winged adults. These fly to Douglas-fir and settle on the lower surface of the current year's needles to lay eggs. The females cover their egg masses with wax and fold their wings over them.

Sistens on Douglas-fir

Sistentes are the progeny of gallicolae migrantes. The nymphs overwinter on the lower surface of current Douglas-fir needles (fig. 3). They are light brown to black in color and secrete a fringe of white wax around the edge of their bodies. They probably go through two nymphal instars in the spring before changing into wax-covered adult females (fig. 4). The progeny of the sistentes are of two kinds: wingless females, the progredientes which remain on Douglas-fir; and winged females, the sexuparae, which migrate back to spruce.

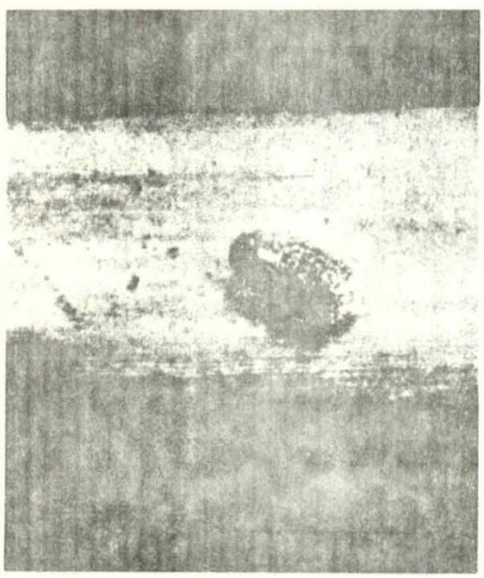

Figure 3.--A sistens nymph overwintering on a Douglas-fir needle. Head is to the left. Note threads of wax on body. (Enlarged about 20 times in length.)

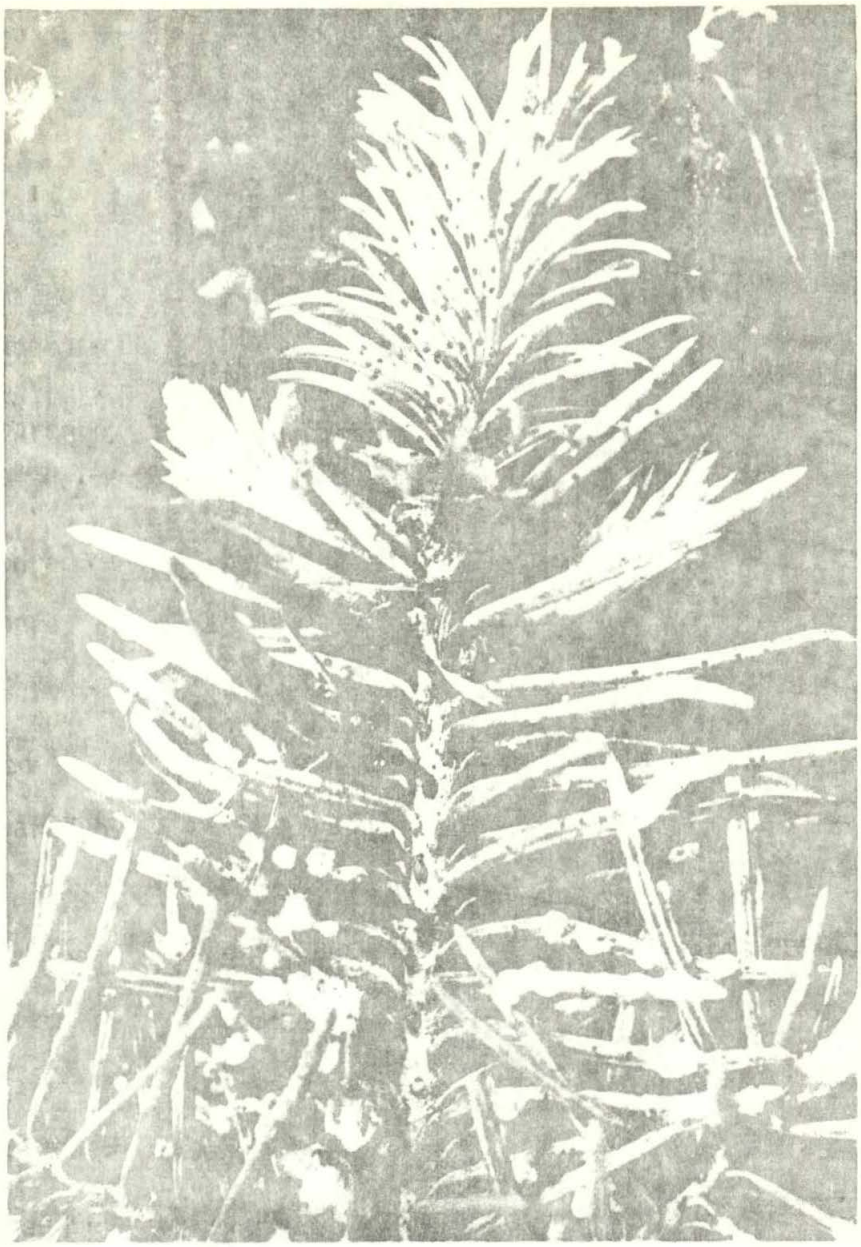

Figure 4.--Infested Douglas-fir branch in June. Adult sistentes are covered with white wax and are laying eggs on the old needles (bottom of picture). Progredientes and sexuparae nymphs are emerging from the eggs and feeding on the new needles (look at black spots on needles at top of picture).

Progrediens on Douglas-fir

Progredientes are the progeny of sistentes. Nymphs (fig. 4) feed on new Douglas-fir needles during the summer. By the middle of August adults lay eggs. Adults produce wax in a flocculent mass. The progeny of this generation overwinter on Douglas-fir with the sistentes. The cycle on Douglas-fir is repeated in the spring with the production of another generation of progredientes.

Sexupara on Douglas-fir

Sexuparae are also the progeny of sistentes. Adults develop wings and migrate from Douglas-fir to spruce. Sexuparae nymphs (fig. 4) feed on the upper surface of new Douglas-fir needles. Feeding causes slightly depressed yellow patches and distortion. There are four nymphal instars. Nymphs are light yellow-brown in color, becoming darker brown after moulting. Wax is not noticeable on the abdomen. Adults fly in August and lay eggs on spruce twigs. The female secretes wax over her eggs and covers them with her wings.

Seasonal Development

There is a wide variation in the development of C. cooleyi. Temperature regulates development the most. Cumming studied the life history at 4,500 feet elevation on the eastern slopes of the Rocky Mountains. The generalized life-cycle determined by her should pertain to seasonal development in most Northern Region areas. A modified diagram of it is shown in Figure 5 below.

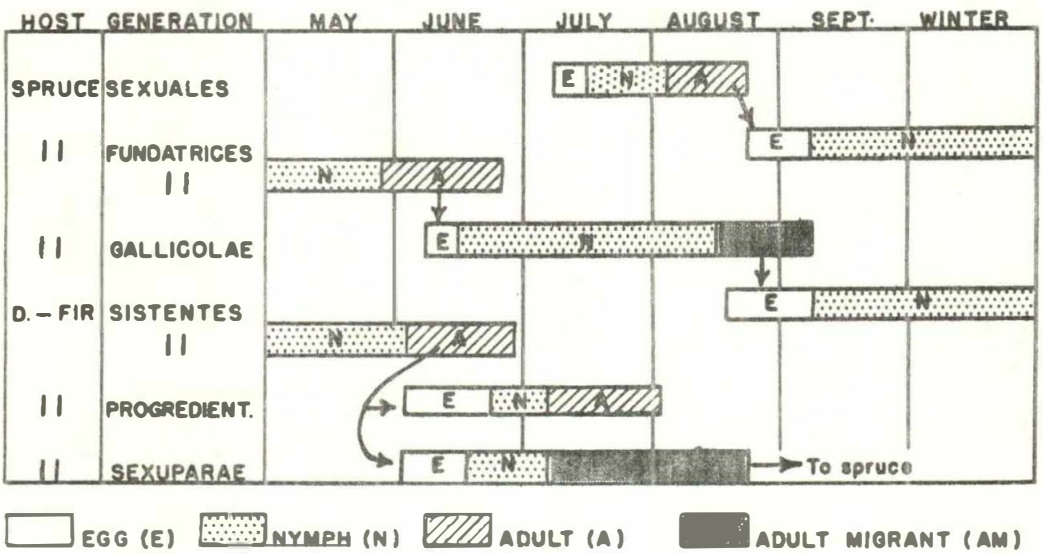

Fig. 5 — Generalized life-cycle of C. cooleyi in the Northern Region.

SUMMARY OF LIFE HISTORY AND HABITS

In August, SEXUPARA adults fly from Douglas-fir to spruce and lay eggs on twigs. SEXUALES nymphs from the eggs feed for 2 weeks near the nodes of old growth, become male and female adults; and after copulation, females lay eggs. FUNDATRIX nymphs emerge, feed for a short time on the needles, then usually overwinter on the stem. In the spring the nymphs develop into adults and lay eggs which produce the GALLICOLA MIGRANS generation. Gallicola nymphs complete the development of galls which were "triggered" by fundatrices feeding on the twigs. The nymphs feed inside the galls until the end of August. They emerge, change into adults, and fly to Douglas-fir needles to lay eggs. SISTENS nymphs emerge, overwinter on current needles, and develop into egg-laying adults by spring. Two different generations emerge from these spring eggs: One generation (sexupara) develops wings and migrates back to spruce (begins cycle again). The other generation (PROGREDIENS) remains wingless, feeds on Douglas-fir during the summer, and lays eggs on this host by September. Progeny from this generation mixes with progeny (sistens) of the gallicola migrans from spruce, and both overwinter on Douglas-fir.

CONTROL

Spruce

Protection from gall formation on spruce can be obtained by spraying infested trees with malathion or nicotine sulfate insecticides. Careful timing of the spray application is necessary. Apply just as the buds break, or about the end of May. This should kill fundatrix nymphs and adults and some early gallicolae nymphs before they cause galls.

Mix the sprays as follows:

Materials	Large amounts	Small amounts
Malathion (25 percent wettable powder)	2 pounds	$\frac{1}{4}$ pound
Water	100 gallons	$12\frac{1}{2}$ gallons
Nicotine sulfate[1/] (40 percent mixture)	2 cups	2 tablespoonfuls
Water	100 gallons	6 gallons
Household detergent (powder)	2 cups	2 tablespoonfuls

1/ Black Leaf-40 is a commercial brand

Keep the malathion solution agitated while spraying so the powder will not settle to the bottom of the mixing container. The materials in the nicotine sulfate spray should be well mixed by stirring.

Both of these sprays give better kill when they are applied on dry or damp foliage (no water droplets present) and during a clear, warm day. Spray all the foliage and stems on an infested tree. Be sure to drench the upper and lower surfaces of the branches until the liquid runs off.

Caution should be used while handling and mixing concentrated malathion and nicotine sulfate. Nicotine is absorbed by the skin rapidly upon contact. It also should not be inhaled. Rubber gloves are recommended for mixing both of these insecticides. Remove outer clothing if it becomes wet with spray and wash skin if solutions are spilled on it.

The aphid population on small ornamental spruce trees can be reduced without spraying by cutting off current galls (green with purple tinge) before the nymphs emerge in August. The middle of July would be a good time to do this. Destroying the galls would also stop the aphids from flying to nearby Douglas-fir trees.

Douglas-fir

Malathion and nicotine sulfate can also be used for killing aphid generations on Douglas-fir foliage. It can be mixed and used as previously described for control of the generations on spruce. Application in May will kill nymphal sistentes; and in June, adult sistentes and their progeny can be killed.

There is a possibility that nymphs on Douglas-fir and spruce could be controlled during September. However, these two insecticides have more killing power when temperatures are higher.